UNIVERSITY OF TECHNOLOGY SYDNEY

AQUEOUS DEPOSITION OF GOLD NANOFILM FOR SOLAR CONTROL

By

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CERTIFICATE OF ORIGINALITY

I certify that the work in this thesis has not previously been submitted for a degree, nor has it been submitted as part of the requirements for a degree, except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in this research work and the preparation of the thesis itself has been fully acknowledged. In addition, I certify that all information sources and literature used are indicated in this thesis.

Xiaoda Xu

5/08/2015

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PREFACE

Part of this thesis have been published in the following journals and peer-reviewed conference proceedings:

[1] X. Xu, T. H. Gibbons and M. B. Cortie, *Spectrally-selective gold nanorod coatings for window glass.* Gold Bulletin, 2006. **in press**.

[2] X. Xu and M. Cortie, *Shape change and color gamut in gold nanorods, dumbbells, and dog bones.* Advanced Functional Materials, 2006. **in press**.

[3] M. Cortie, X. Xu and M. Ford, *Effect of composition and packing configuration on the dichroic optical properties of coinage metal nanorods.* Physical Chemistry Chemical Physics, 2006. **8**: 3520

[4] X. Xu, M. B. Cortie and M. Stevens, *Effect of glass pre-treatment on the nucleation of semi-transparent gold coatings.* Materials Chemistry and Physics, 2005. **94**: 266.

[5] K. E. Peceros, X. Xu, S. R. Bulcock and M. B. Cortie, *Dipole-dipole plasmon interactions in gold-on-polystyrene composites.* Journal of Physical Chemistry B, 2005. **109**: 21516

[6] M. Cortie, X. Xu, H. Zareie, H. Chowdhury and G. Smith. *Plasmonic heating of gold nanoparticles and its exploitation*. Smart Materials, Nano-, and Micro-Smart Systems II. 2005. Sydney, Australia.

[7] H. Chowdhury, X. Xu, P. Huynh and M.B. Cortie, *Radiative heat transfer across glass coated with gold nanoparticle.* ASME Journal of solar energy engineering, 2005. **127**: 70.

[8] X. Xu, M. Stevens and M. B. Cortie, *In situ precipitation of gold nanoparticles onto glass for potential architectural applications.* Chemistry of Materials, 2004. **16**: 2259.

ABSTRACT

In this study, I have demonstrated two ways to deposit nanoscale gold coatings on glass for solar control purposes. Coatings produced by *in situ* deposition showed a variation in colour from red, to purple to blue in transmission, caused by the surface plasmons of isolated particles and the inter-particle interaction of gold nanospheres. The absorption peak was in the upper visible and near-infrared. The colour and transmission spectrum of these coatings were controlled by nucleation, growth and aggregation of the gold nanospheres. The optical spectrum was simulated by Discrete Dipole Analysis (DDA), which revealed that the absorption peaks were strongly influenced by the ratio of particle size to interparticle spacing. The mechanical properties of these gold nanoparticle coatings were also investigated by nanoindentation. This indicated the film of gold nanoparticles showed similar mechanical properties to those of bulk gold.

The seed-mediated method for synthesis of gold nanorods was also investigated. It was found that the pH, Ag^+, surfactant and seed solution play important roles in controlling the aspect ratio. Ag^+ is strongly absorbed by the gold nanorods. Ag/Au in as-prepared rods changed only slightly from 1:1.78 to 1:1.35, while the ratio in solution changed greatly from 1:10 to 1:2.5. A double-layer micellar structure in the surfactant solution was proposed as the explanation for the synthesis of gold nanorods by the seed-mediated method. The transmission spectra of different shapes of gold nanorods were also simulated by the DDA method, while the gamut of colours of gold nanorods during growth was mapped onto the CIE-LAB colour space. Self-assembled coatings of gold nanorods provided better spectral selectivity between infrared and visible region than was possible with spheres. Numerical simulations confirmed this, and showed that a mixture of nanorods of varying aspect ratio could achieve better spectral selectivity with a low gold loading. However, the further development of gold nanorod coatings requires the availability of an effective method to produce long rods.

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